

WHAT IS CLAIMED IS:

1 1. A method for determining total leakage power for an integrated circuit (IC)
2 having a plurality of circuit macros, comprising the steps of:

3 a) estimating a present total macro power for each of said plurality of circuit
4 macros;

5 b) calculating a macro temperature for each of said plurality of circuit macros
6 in response to said present total macro power using a multi-dimensional thermal
7 model for a thermal structure for removing heat from said IC;

8 c) calculating a macro voltage for each of said plurality of circuit macros in
9 response to a current drawn by each of said macros using a multi-dimensional
10 electrical model for a power distribution structure for delivering power from a power
11 supply to said IC, wherein a value of said current is set as a function of said total
12 macro power;

13 d) calculating a present leakage power for each of said circuit macros in
14 response to a corresponding macro temperature and macro voltage;

15 e) calculating a present dynamic power for each of said plurality of said
16 circuit macros in response to a corresponding macro temperature and macro voltage;

17 f) calculating said present total macro power for each of said plurality of
18 circuit macros in response to said present leakage power and said present dynamic
19 power; and

20 g) repeating steps b) through f) if said present leakage power has not
21 converged to a final leakage power and stopping if said present leakage power has
22 converged to said final leakage power for each of said plurality of circuit macros.

1 2. The method of claim 1 further comprising the step of adding said total macro
2 power of each of said circuit macros generating said total leakage power.

1 3. The method of claim 1 wherein a macro voltage at each of said plurality of
2 circuit macros is set to a nominal voltage during the step of estimating said total
3 macro power.

1 4. The method of claim 1, wherein said current through said power distribution
2 network has a value corresponding to said present total macro power divided by said
3 macro voltage.

1 5. The method of claim 1, wherein said multi-dimensional power distribution
2 model comprises a grid network having a multiplicity of circuit nodes coupled
3 together with said resistor.

1 6. The method of claim 5, wherein said multi-dimensional power distribution
2 network comprises three spatial dimensions.

1 7. The method of claim 1, wherein said multi-dimensional thermal model for
2 removing heat from said IC comprises a thermal model for said IC, a thermal model
3 for thermally coupling said IC to a corresponding electronic packaging and a thermal
4 model for thermally coupling said IC to a corresponding heat sink.

1 8. The method of claim 7, wherein said thermal model for said IC, said thermal
2 model for thermally coupling said IC to a corresponding electronic packaging, and
3 said thermal model for thermally coupling said IC to a corresponding heat sink,
4 wherein each model comprises a grid network having a multiplicity of nodes coupled
5 together with thermal resistor elements.

1 9. The method of claim 1, wherein said macro temperature for each of said
2 plurality of circuit macros is calculated using a linear solver to solve sets of equations
3 defining said multi-dimensional thermal model.

1 10. The method of claim 1, wherein said macro voltage for each of said plurality
2 of circuit macros is calculated using a linear solver to solve sets of equations defining
3 said multi-dimensional power distribution network.

1 11. The method of claim 1, wherein said present leakage power for each of said
2 plurality of circuit macros is calculated using a circuit analysis program having data
3 relating leakage power as a function of process parameters, power supply voltage,
4 circuit configurations, temperature, and logic states.

1 12. A computer program product for determining leakage power for an integrated
2 circuit (IC) having a plurality of circuit macros, said computer program product
3 embodied in a machine readable medium, including programming for a processor,
4 said computer program comprising a program of instructions for performing the
5 program steps of:

6 a) receiving an estimated present total macro power for each of said plurality
7 of circuit macros;

8 b) calculating a macro temperature for each of said plurality of circuit macros
9 in response to said present total macro power using a multi-dimensional thermal
10 model for a thermal structure for removing heat from said IC;

11 c) calculating a macro voltage for each of said plurality of circuit macros in
12 response to a current drawn by each of said macros using a multi-dimensional
13 electrical model for a power distribution structure for delivering power from a power
14 supply to said IC, wherein a value of said current is set as a function of said total
15 macro power;

16 d) calculating a present leakage power for each of said circuit macros in
17 response to a corresponding macro temperature and macro voltage;

18 e) calculating a present dynamic power for each of said plurality of said
19 circuit macros in response to a corresponding macro temperature and macro voltage;

20 f) calculating said present total macro power for each of said plurality of
21 circuit macros in response to said present leakage power and said present dynamic
22 power; and

23 g) repeating steps b) through f) if said present leakage power has not
24 converged to a final leakage power and stopping if said present leakage power has
25 converged to said final leakage power for each of said plurality of circuit macros.

1 13. The computer program product of claim 12 further comprising the step of
2 adding said total macro power of each of said circuit macros generating said total
3 leakage power.

1 14. The computer program product of claim 12 wherein a macro voltage at each
2 of said plurality of circuit macros is set to a nominal voltage during the step of
3 estimating said total macro power.

1 15. The computer program product of claim 12, wherein said current through said
2 power distribution network has a value corresponding to said present total macro
3 power divided by said macro voltage.

1 16. The computer program product of claim 12, wherein said multi-dimensional
2 power distribution model comprises a grid network having a multiplicity of circuit
3 nodes coupled together with said resistor.

1 17. The computer program product of claim 16, wherein said multi-dimensional
2 power distribution network comprises three spatial dimensions.

1 18. The computer program product of claim 12, wherein said multi-dimensional
2 thermal model for removing heat from said IC comprises a thermal model for said IC,
3 a thermal model for thermally coupling said IC to a corresponding electronic
4 packaging and a thermal model for thermally coupling said IC to a corresponding
5 heat sink.

1 19. The computer program product of claim 18, wherein said thermal model for
2 said IC, said thermal model for thermally coupling said IC to a corresponding

3 electronic packaging, and said thermal model for thermally coupling said IC to a
4 corresponding heat sink, wherein each model comprises a grid network having a
5 multiplicity of nodes coupled together with thermal resistor elements.

1 20. The computer program product of claim 12, wherein said macro temperature
2 for each of said plurality of circuit macros is calculated using a linear solver to solve
3 sets of equations defining said multi-dimensional thermal model.

1 21. The computer program product of claim 12, wherein said macro voltage for
2 each of said plurality of circuit macros is calculated using a linear solver to solve sets
3 of equations defining said multi-dimensional power distribution network.

1 22. The computer program product of claim 12, wherein said present leakage
2 power for each of said plurality of circuit macros is calculated using a circuit analysis
3 program having data relating leakage power as a function of process parameters,
4 power supply voltage, circuit configurations, temperature, and logic states.